the house healthy, rearing of infants, prevention of the spread of infectious diseases, preparation of food and kindred subjects, knowledge of which is so much needed in our crowded neighbourhoods. The questions of poisonous dyes in domestic fabrics, of smoke abatement, of dust collection, and the prevention of cholera have been investigated and reported upon by special committees appointed for the purpose. The Health Exhibition held by the Society last June was commented upon, and the Secretary stated that more than 100 members had joined the Society during the past year.

THE great interest manifested in the International Health Exhibition is shown by the fact that application has been made, by British exhibitors alone, for space five times as great as that actually at the disposal of the Executive Council. Information has recently been received that the French Government has appointed a Commission; and Italy—owing in a great measure to the individual exertions of a member of the Executive Council—will, it is hoped, take an active part. A portion of the Educational Section of the Exhibition will be located in the Central Institute of the City of London Technical Guilds, the handsome building in course of erection in the Exhibition Road, which has been kindly placed at the disposal of the Executive Council. The Royal Albert Hall with its musical attractions will now form an integral part of the Exhibition; and the Aquarium, a popular feature of the late Fisheries Exhibition, will continue as an important part of the Health Exhibition. In the Dress Section the most popular exhibit will probably prove to be a series which is being prepared illustrative of English dress of all ranks of life, from the time of the Conquest to George IV. An International Congress on Education will be held, and conferences and lectures will conduce to the elucidation of the subjects of the Exhibition. It is also proposed to have a library and reading-room in connection with the Exhibition, which will be open to all visitors, under proper regulations, while the Exhibition is open. The library will consist of books on various subjects comprised in the classification of the Exhibition, both English and foreign. Application has been addressed to foreign and colonial Governments, asking them for copies of reports and statistics on sanitary and educational matters, and a circular is being sent out to authors and publishers requesting them to contribute works of a similar character.

AT a meeting of the Society of Telegraph Engineers held on the 13th inst., a short paper, "Notes on a Train Lighting Experiment," was read by Mr. W. H. Massey of Twyford, who strongly advocated the use of a small engine and dynamo-machine placed on each locomotive for working incandescent lamps, by means of which railway carriages would be much better lighted than at present for less than is paid for gas. An interesting discussion took place, and the meeting was adjourned to the 27th inst., when Mr. Massey is expected to reply.

THE March number of *Petermann's Mittheilungen* contains a letter from Dr. Junker dated Sami, 6½° N. lat., 25° E. long., December 8, 1882, in which he gives a brief statement of the results of his journeys in the Upper Welle and Bomokandi, with notes on the various tribes that inhabit the region. Dr. Junker did some further exploring work to the south-west of his station in 1883; but his numerous cases of collections have been lost in a fire which consumed the building where they were stored.

THE additions to the Zoological Society's Gardens during the past week include a Squirrel Monkey (*Chrysothrix sciurea*) from Guiana, presented by Mrs. Dundas; a Leopard (*Felis pardus*) from Africa, presented by Mr. S. Cresswell; a West Indian Rail (*Aramides cayennensis*) from South America, presented by Mrs. Edward Hairby; a Kestrel (*Tinnunculus alaudarius*), British, presented by Mr. F. E. Baum; a Common Viper (*Vipera berus*), British, presented by Mr. W. H. B. Pain; two Mute Swans (*Cygnus olor*), European, four Redshanks (*Totanus calidris*), British, purchased.

PHYSICAL NOTES

PROF. J. H. POYNTING has published in the *Proceedings of the Birmingham Philosophical Society* a note on a method of calculating the velocity of propagation of waves of longitudinal and transverse disturbances by the rate of transfer of energy. The paper discusses the two cases by the method originally propounded by Lord Rayleigh.

WE have received from Madame Plateau copies of three posthumous memoirs by her late husband, the lamented Prof. J. Plateau. Their titles are: "Quelques Expériences sur les lames liquides minces (deuxième note)"; "Sur l'Observations des Mouvements très rapides"; and "Bibliographie analytique des Principaux Phénomènes subjectifs de la Vision." The first of these *brochures* relates to the preservation of the glyceric fluid, to certain appearances in very thin films, and on the constitution of foam. In the second the writer contrasts four methods: the rotating mirror, the stroboscopic method, the intermittent illumination by electric sparks, and the process of multiple instantaneous photography. The third is a supplement for the years 1880–1882 to the well-known bibliography compiled by the deceased *savant*.

WE have also received the first instalment of vol. i. of the *Bulletin de la Société Internationale des Électriciens* (January 1, 1884), containing the laws of the new society, a list of founders, and one of the members already enrolled, now numbering about 1200, of whom only a few are Englishmen.

PROF. QUINCKE has lately read before the Berlin Academy a paper on the measurement of magnetic forces by hydrostatic pressure. He has examined the magnetic inductive capacity, or, as he calls it, the "di-magnetic constant" of a number of liquids, by observing their rise in an open-air manometer when subjected to a field of powerful, but known, intensity, the observed change of pressure being proportional to the square of the intensity of the field and to the difference between the magnetic inductive capacity of the substance and that of the air. A number of tables are given, with copious numerical data. The di-magnetic constant of such liquids as ether, alcohol, turpentine, nitric acid, bisulphide of carbon, glycerine, water, &c., showed small negative values; whilst the values were positive, and in many cases much more considerable for solutions of chloride of iron, chloride of manganese, sulphate of nickel, and of cobalt, and for solutions of magnetic salts in general.

A SLIGHT mistake occurred in a note on p. 276, in which Bunsen's estimation that in three years 5·135 cubic centimetres of carbonic dioxide was absorbed by a square metre of glass was stated as the absorption of one square centimetre.

THE CHEMICAL WORK OF WÖHLER[1]

IT seems fitting that these walls, which have vibrated in sympathy with that brilliant eulogy of Liebig which Prof. Hofmann pronounced some nine years ago should hear something of him whose life-long association with Liebig has exercised an undying influence on the development of scientific thought. The names of Frederick Wöhler and Justus Liebig will be linked together throughout all time. The work which they did in common makes an epoch in the history of chemistry. No truer indication of the singular strength and beauty of their relations could be given than is contained in a letter from Liebig to Wöhler, written on the last day of the year 1871. "I cannot let the year pass away," writes Liebig to Wöhler, "without giving thee one more sign of my existence, and again expressing my heartfelt wishes for thy welfare and the welfare of those that are dear to thee. We shall not for long be able to send each other New-Years' greetings, yet, when we are dead and mouldering, the ties which have united us in life will still hold us together in the memory of men as a not too frequent example of faithful workers who, without envy or jealousy, have zealously laboured in the same field, linked together in the closest friendship."

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[1] A lecture delivered at the Royal Institution on Friday evening, February 15, 1884, by Prof. Thorpe, F.R.S.

And yet, bound as they were in the ties of a friendship the purity and warmth of which were but characteristic of the men, and although each influenced the other's walk and work in life to a degree which it is almost impossible to gauge, such was the strength of their individuality and such the force of their genius that, without a doubt, either would have been a great figure in the history of science if the other had not existed.

The conditions under which minds of the highest type arise and develop have on more than one occasion engaged the attention of this audience. Although there were circumstances in Wöhler's surroundings which in early life may have influenced the bent of his mind, it is not easy to see whence sprang that passionate love of nature which was so strikingly exhibited in the man. His father, August Anton Wöhler, was formerly an equerry in the service of the Elector William II. of Hesse; he afterwards came to live at Frankfort, and became a leading citizen of that town. His wise liberality and public spirit are commemorated in the Wöhler Foundation and Wöhler School, institutions known to every Frankforter. His mother was connected by marriage with the minister of Eschersheim, a village near Frankfort, and it was in the minister's house that Frederick Wöhler first saw the light, on July 31, 1800. Even in early youth his passion for experimenting and collecting manifested itself, to the neglect not unfrequently of the lessons of the gymnasium; indeed it would appear that during his school career Wöhler was not characterised by either special diligence or knowledge. The bent of his mind towards natural science was directed by Dr. Buch, a retired physician who had devoted himself to the study of chemistry and physics; and it was in the kitchen of his patron's house that he prepared the then newly-discovered element selenium, of which an account was afterwards sent by Dr. Buch to Gilbert's *Annalen*, with Wöhler's name at the head of it. The elder Wöhler appears to have been a man of considerable artistic feeling, and under his direction the son was taught sketching and otherwise educated in that perception of natural beauty which comes out so strikingly in his after life; and he was encouraged to make himself familiar with the literature which the genius of Schiller and Goethe has ennobled. He had, moreover, to thank his father for that love of physical exercise and passion for outdoor life which reacted so beneficially upon his development, and contributed so largely to the uniformly good health which he enjoyed to within a few days of his death. Mainly, it would seem, because his father had been there before him, Wöhler, in his twentieth year, entered the University of Marburg. It was his own and the family's wish that he should study medicine, and he accordingly put his name down for the lectures of Bünger on Anatomy, Gerling on Physics and Mathematics, and Wenderoth on Botany. He found time also to attend Ullmann's classes on Mineralogy; and although he declined to hear Wurzer's lectures on Chemistry, he by no means neglected that science. He transformed his living-room into a laboratory, and to the great, and perhaps not undeserved, disgust of his landlady, occupied himself with the preparation and study of the properties of prussic acid, thiocyanic acid, and other cyanogen compounds. He discovered at that time, without knowing that Sir Humphry Davy had anticipated him, the beautifully crystalline but intensely poisonous iodide of cyanogen; and in the little paper on cyanogen compounds which his good friend Dr. Buch communicated to Gilbert's *Annalen* for him we have the first description of the remarkable behaviour of mercuric thiocyanate on heating, which has astonished and amused us in the so called "Pharaoh's Serpent."

Wöhler, attracted by the fame of Leopold Gmelin, left Marburg for Heidelberg. His main idea was to hear the lectures of that distinguished man, but Gmelin declared this to be unnecessary and a waste of time. Wöhler in fact never attended any systematic lectures on chemistry; he had access, however, to the old cloisters which at that time constituted the Heidelberg laboratory, and there began the work on cyanic acid which some four or five years later was destined to culminate in the great discovery of the synthesis of urea. His association, at this time, with Tiedemann, who was engaged in physiological chemical investigation with Gmelin, had also considerable influence in determining the direction of much of his future work, whilst its immediate effect was the publication in Tiedemann's *Zeitschrift für Physiologie* of the results of an inquiry into the transformation experienced by various substances, organic and inorganic, in their passage through the organism. In 1823 Wöhler obtained his degree, when, on Gmelin's advice, he determined to follow his master's example, and abandon medicine for chemistry. At that time the great Swedish chemist Berzelius was at the summit of his fame: his masterly analytical skill, no less than his labours towards the development of chemical theory, had made him supreme among the chemists of Europe, and to Stockholm therefore, Wöhler, acting on the advice of Gmelin, determined to go. He was warmly welcomed by Berzelius, on whom his communications to Gilbert's *Annalen* had made a favourable impression, and with the offer of a place in the private laboratory of the illustrious Swede, Wöhler set out for the Scandinavian capital. Of his experiences with Berzelius his pupil has left us a delightful account. It is valuable not only as a charming character-sketch of the great teacher, but also from the side-light it throws upon the nature and disposition of Wöhler and himself. It is interesting, too, as an account of the mode in which Berzelius worked and taught, and as showing how the typical laboratory of that time contrasted with the temples which have since been reared by the disciples of Hermes.

"With a beating heart," says Wöhler, "I stood before Berzelius's door and rang the bell. It was opened by a well-clad, portly, vigorous-looking man. It was Berzelius himself. . . . . As he led me into his laboratory I was as in a dream, doubting if I could really be in the classical place which was the object of my aspirations. . . . I was at that time the only one in the laboratory: before me were Mitscherlich and Heinrich and Gustav Rose: after me came Magnus. The laboratory consisted of two ordinary rooms furnished in the simplest possible way; there were no furnaces nor draught places; neither gas nor water service. In one of the rooms were two common deal tables; on one of these worked Berzelius, the other was intended for me. On the walls were a few cupboards for the reagents; in the middle was a mercury trough, whilst the glass-blower's lamp stood on the hearth. In addition was a sink, consisting of an earthenware cistern and tap, standing over a wooden tub, where the despotic Anna, the cook, had daily to clean the apparatus. In the other room were the balances, and some cupboards containing instruments: close to was a small workshop fitted with a lathe. In the neighbouring kitchen, in which Anna prepared the meals, was a small but seldom-used furnace and the never-cool sand-bath."

Wöhler's first exercises were in mineral analysis, in order that he might become acquainted with Berzelius's special methods and manipulative procedure. At that time he prepared, among other products, some new compounds of tungsten, notably the beautifully crystallised monoxychloride and the tungsten sodium-bronze ($Na_2W_3O_9$), which some twenty-five years later was introduced into the arts as a bronze powder. It was, however, with his investigation on cyanic acid that both he and Berzelius were mainly interested. In Berzelius's opinion the existence of this body was of importance from the light it seemed to him to throw upon the validity of the new chlorine theory. "I was surprised," says Wöhler, "to hear him, the hitherto steadfast upholder of the old notion, now always talk of *chlorine* instead of oxidised hydrochloric acid. Once, when Anna, in cleaning some vessel, remarked that it smelt strongly of oxymuriatic acid, Berzelius said, 'Hearest thou, Anna, thou must no longer speak of oxidised muriatic acid; thou must call it *chlorine:* that is better.'" With what feelings would Davy have listened to that colloquy between the Swedish philosopher and his factotum! Chlorine was discovered by Berzelius's illustrious countryman, Scheele, but its true nature was first demonstrated in the laboratory of the Royal Institution.

A couple of months were now spent in travel with Berzelius, in company with the two Brongniarts, Alexander the geologist and Adolph the botanist, during which they explored the greater portion of the geologically interesting parts of Southern Sweden and Norway, and collected rich stores of those wonderful minerals for which Scandinavia is famous. Scandinavia is no less famous for salmon and trout, and it was on his return from a fishing expedition in Norway that the travellers met with Davy, who, as readers of "Salmonia" know, handled his rod with great zest and zeal. Wöhler, who as a boy had learned the story from his friend Dr. Buch, of the isolation of the alkaline metals by Davy, and who, aided by his little sister, whose business it was to blow the bellows, had toiled, not unsuccessfully, to make potassium in the kitchen fire, was presented to the famous chemist.

On the return to Stockholm, Wöhler took leave of Berzelius and prepared to return to Germany. Of his association with this great man Wöhler had ever the kindliest memories. Although the outcome of much of his subsequent work, or at least much of that which he did in concert with Liebig, might be said to bring him in occasional conflict with Berzelius's cherished convictions on points of chemical theory, the master and pupil remained to the end bound together in the warmest friendship. Scarcely a month passed without an exchange of letters. Those from Berzelius were religiously preserved by Wöhler, who, after his master's death in 1848, presented them, to the extent of some hundreds, to the Swedish Academy of Sciences. We are told that in the later letters the "trauliche Du" appears in place of the more formal "Sie," and that "*Totus et tantus tuus*" is a not unfrequent signature.

Wöhler's gratitude and almost filial reverence are seen in the circumstance that even in the full tide of his vigour, and when time was doubly precious to him, he continued to charge himself with the yearly translation of Berzelius's *Jahresbericht* into German. It is easy to trace the influence of Wöhler's contact with Berzelius in his after work. To begin with, the men had much in common: their sympathies were as catholic as science itself, and they ranged at will over every department of chemical knowledge. Wöhler attacked the composition of a mineral with as much ardour as he did the preparation of an organic compound: to him the problems of physiological chemistry were not more important than the isolation of a rare earth or the perfection of some analytical method. The artificial barriers and fancied lines of demarcation in the science seemed to have no existence for Wöhler: indeed, it was the crowning triumph of his work to break down such barriers almost at a stroke, and to demonstrate the irrationality of these attempts to draw distinctions regardless of differences. The history of chemistry is indeed like that of the nation which has done so much to advance it: its unity to-day is as complete as that of Germany itself.

Wöhler was now to embark on his academic career, and under the advice of Gmelin and Tiedemann he prepared to settle in Heidelberg as *privat docent.* But to Heidelberg he was not destined to go. His work had already been gauged by such men as Leopold von Buch, Poggendorff, and Mitscherlich, and these, without his knowledge, had strongly recommended his election to the vacant teachership of chemistry in the newly-founded Trade School in Berlin. Berzelius advised him to accept the post, and to Berlin accordingly Wöhler went in 1825. He was now in possession of a laboratory which he could call his own, and he had to justify that possession by the use which he made of it. One of the problems which he now attacked was the isolation of *aluminium*, a metallic radicle more abundant and more widely diffused than any other of the fifty bodies we are accustomed to designate as metals. He succeeded in obtaining the body by the method which, nearly twenty years after, was worked out on a manufacturing scale by Sainte-Claire Deville. Deville caused the first bar of the metal thus procured to be struck as a medal, with the image of Napoleon III. on the one side, and the name Wöhler with the date 1827 on the other, and some time after the Emperor simultaneously designated the two chemists officers of the Legion of Honour.

But of the twenty-two memoirs and papers which Poggendorff's *Annalen* exhibits as the outcome of Wöhler's activity and power of work during his six years' stay in Berlin, that on the artificial formation of urea is by far the most important. No single chemical discovery of this century has exercised so great an influence on the development of scientific thought, and the words with which Wöhler closes his account of the molecular transformation of ammonium cyanate—a body of purely inorganic origin—into urea—a substance which of all that might be named is the most characteristic of the action of the so-called vital force—are full of meaning: "This unexpected result," he says, "is a remarkable fact, in so far as it presents an example of the artificial formation of an organic body, and indeed one of animal origin, out of inorganic materials." "The synthesis of urea," says Prof. Hofmann in his account of Wöhler's life-work, "was an epoch-making discovery in the real sense of that word. With it was opened out a new domain of investigation upon which the chemist instantly seized. The present generation, which is constantly gathering such rich harvests from the territory won for it by Wöhler, can only with difficulty transport itself back to that remote period in which the creation of an organic compound within the body of a plant or an animal appeared to be conditioned in some mysterious way by the vital force, and they can hardly realise the impresssion which the building up of urea from its elements then made upon men's minds. And yet it cannot be said that chemists were unprepared for this discovery. Men were long ago in the habit of perceiving that bodies of mineral origin were but the types of those met with in the animal and vegetable organism—in both classes there were the same differences in states of aggregation, the same mutual transformations, the same crystalline forms, the same constancy in combining relations, the same conjunction of the elements according to the weights of their atoms or in multiples of these, in both classes the appearance of the same species of compounds. But all attempts to build up organic compounds from their elements, as this for a large number of mineral substances had already been done, had hitherto been futile. The chemists of that period had nevertheless the presentiment that even this barrier must fall, and one can conceive the feeling of joy with which the gospel of a new unified chemistry was hailed by the intellect of that time. With the revolution thus effected in the ideas of men, science was directed into new paths and unto new goals. Who does not know with what zeal these paths have been trodden, and how many of these goals have been reached!"

But if at this time Wöhler made a great discovery for the world, he also, at about the same time, made a great discovery for himself: he discovered Liebig. The manner in which the two men were brought together is worth mentioning, for it would seem almost as if the hand of destiny was in it. At about the time that Wöhler was at Stockholm thinking and working on cyanic acid, Liebig was at Paris engaged with Gay Lussac on the study of the metallic compounds of an acid which, on account of their formidable explosive properties, has received the not inappropriate name of fulminic acid. Liebig, with rare skill and courage, had determined the composition of that acid, and had been rewarded by the honour of a waltz with Gay Lussac, it being the habit of that distinguished philosopher, as he explained to the astonished young German doctor, to express his ecstasy on the occasion of a new discovery in the poetry of motion. But the most extraordinary result of that investigation was to show that the terribly explosive fulminic acid and the innocuous cyanic acid were of identical composition. The idea that bodies could exist of identical ultimate composition—that is composed of the same elements united in the same proportion and yet possess essentially different properties, in other words be absolutely dissimilar things, was new to science; Berzelius, the great chemical lawgiver of his time, scouted the notion as absurd; to him it was impossible to conceive that identity in elementary composition should not result in identity of properties. And yet, later on, Berzelius was forced to realise the fact by the discovery by his pupil Wöhler of the molecular transformation of ammonium cyanate into urea, and to coin for us the word *isomerism*, by which that fact is denoted.

It was thus from the singular circumstance that Wöhler and Liebig were at the outset of their career engaged upon the elucidation of the nature of two bodies of identical composition, but of dissimilar origin, dissimilar relations, and very different properties, that they were brought into juxtaposition. They desired to know each other: they met in the house of a mutual friend at Frankfort, and the names of Liebig and Wöhler became henceforth linked together for all time.

The origin of that partnership, so fruitful in consequences for science, may be seen in the following characteristic letter:—

"FREDERICK WÖHLER TO JUSTUS LIEBIG

"*Sacrow, near Potsdam, June* 8, 1829

"DEAR PROFESSOR,—The content of your last letter to Poggendorff has been communicated to me by him, and I am glad that it affords me an opportunity of resuming the correspondence which we began last winter. It must surely be some wicked demon that again and again imperceptibly brings us into collision with our work, and tries to make the chemical public believe that we purposely seek as opponents these apples of discord. But I think he is not going to succeed. If you are so minded, we might, for the humour of it, undertake some chemical work together, in order that the result might be made known under our joint names. Of course, you would work in Giessen, and I in Berlin, after we were agreed upon the plan, and had communicated with each other from time to time as to its progress. I leave the choice of subject entirely to you.

"I am very glad that you have also determined the identity of pyrouric acid, and cyanic [cyanuric] acids. L. Gmelin would say: 'God be thanked, there is one acid the less!' . . .

"Yours, "WÖHLER"

Liebig acceded to the proposition at once, and suggested some problem on the chemical nature of nitrogen; this Wöhler found himself unable to undertake, as it involved the use of chlorine, to the action of which he was at all times extremely susceptible. On the other hand, he proposed to Liebig that they should continue in common a research on mellitic acid, which he himself had begun. Their joint investigation on this body made its appearance within the following year.

It would be quite impossible within the limits of an hour to attempt to give you anything approaching to a complete analysis of Wöhler's work. In all, he was the author of 275 memoirs and papers, and of these fifteen were published in concert with Liebig. I must therefore confine my selection from this vast amount of material to those papers which are of paramount importance from the influence which they have exerted on chemical theory or on the development of the chemical arts.

Very shortly after the publication of the work on mellitic acid Wöhler proposed to Liebig a joint investigation on cyanuric acid, in the course of which he observed the extraordinary transformation of that acid into cyanic acid, and the reconversion of the cyanic acid into cyanuric acid—one of the most remarkable instances of molecular rearrangement known to the chemist. The work progressed little for some months, owing to the demands made by Berzelius's *Jahresbericht* on Wöhler's time. "Wirf die Schreiberei zum Teufel," wrote Liebig, "und gehe in das Laboratorium, wohin Du gehörst." It was that functionary, doubtless, who in due time carried off the writing to his master, the printer. Wöhler went back to his laboratory, and in a few weeks the two investigators had obtained the clue to the puzzle. Liebig wrote to Wöhler: "Now that I have received your experiments the whole thing is cleared up, and with what satisfaction for us! The matter is now decided: the cyanic aid of Serullas is identical with that from urea. . . . Ich bin ganz närrisch vor Freude, dass unser Kindlein nun fehlerlos in die Welt gesetzt wird, ohne Buckel oder Klumpfuss."

[It had been suggested to attack the fulminic acid again.] "The fulminic acid we will allow to remain undisturbed. Like you, I have vowed to have nothing more to do with this stuff. Some time back I wanted, in connection with our work, to decompose some fulminating silver by means of ammonium sulphide; at the moment the first drop fell into the dish the mass exploded under my nose. I was thrown backwards, and was deaf for a fortnight, and became almost blind."

The work on cyanic acid appeared in Poggendorff's *Annalen* during the last month of 1830, and Wöhler was able to send the "Kindlein" "im neuen Kleide," as he says, with a New Year's greeting to his friend. Liebig had suggested fresh work, but at the moment Wöhler was in no humour to attack anything organic. The Swedish chemist, Sefström, had just announced the existence of a new element in the slag of certain iron ores, and this very substance had slipped through Wöhler's fingers unperceived. "I was an ass," he wrote to his friend, "not to have detected it two years ago in the lead ore from Zimapan in Mexico. I was busy with its analysis, and had found something strange in it, when I was laid up for some months in consequence of breathing hydrofluoric acid, and so the matter was allowed to rest. Meanwhile Berzelius sends me word of its discovery by Sefström in Swedish bar iron and in slag. It is very like chromium, and just as remarkable. Moreover, it is the same metal that Del Rio found in the Mexican lead ore, and called erythronium: Descotils, however, had declared this ore to be lead chromate."

Wöhler, no doubt, found a ready sympathiser in Liebig, to whom, not many years before, a similar experience had happened. We all know the story of the young chemist whose unscientific use of the imagination cost him the discovery of the element *bromine*. Wöhler had sent some of the substance to Stockholm, and Berzelius wrote as follows:—

"JACOB BERZELIUS TO FREDERICK WÖHLER

"*Stockholm, January* 22, 1831

"As to the small quantity of the body marked ? I will relate the following story:—'In the far north there lived in the olden time the goddess Vanadis, beautiful and gracious. One day there came a knock at her door. The goddess was in no hurry, and thought "They can knock again"; but there came no further knock, for he who knocked had passed on. The goddess, wondering who it could be that cared so little to be let in, ran to the window and recognised the departing one. "Ah!" said she to herself, "it is that lazy fellow, Wöhler! He richly deserves his name, since he cares so little to come in." Some days after, some one else knocked, repeatedly and loud. The goddess opened the door herself; it was Sefström who entered, and, as a consequence of their meeting, vanadium came to light.' Your specimen with the ? is, in fact, vanadium oxide.

"But he that has found the mode of artificially forming an organic body can well renounce the discovery of a new metal; indeed, one might have discovered ten unknown elements without as much skill as attaches to the masterly work which you and Liebig have carried out together and just communicated to the scientific world."

In 1831 Wöhler was called from Berlin to Cassel, and for some little time he was wholly engaged in the planning and erection of his new laboratory at the Gewerbe-Schule in that town. In the spring of the following year he was again ready for a new research; and this time it was to be the finest piece of work that the two investigators jointly engaged in. It was, in fact, to be the classical research on bitter almond oil. On May 16, 1832, Wöhler wrote to Liebig:—"Ich sehne mich nach einer ernsten Arbeit, sollten wir nicht die Confusion mit dem Bittermandelöl in's Reine bringen? Aber woher Material?" It must have been a *förscherblick* amounting to inspiration which led Wöhler to take up this subject; but neither he nor Liebig could have been wholly conscious of the consequences which were to follow from their work. To-day oil of bitter almonds is made artificially in Germany by the hundredweight: at that time the investigators could only obtain it in small quantities from Paris. They had indeed to thank Pelouze for the material with which they worked. Wöhler made this his greatest research under the cloud of a great sorrow: after barely two years of married life he lost his wife. Liebig, in the tenderest manner, brought him over to Giessen, and sought to win him from his grief and the sense of his loneliness by his company and the wholesome distraction of their joint work made side by side.

On August 30, 1832, Wöhler wrote to Liebig from Cassel:—

"I am here back again in my darkened solitude. I do not know how I shall thank you for the affection with which you received me and kept me by you for so long. How happy was I that we could work together face to face.

"I send you with this the memoir on bitter almond oil. The writing has taken me longer than I anticipated. I want you to read through the whole with the greatest care, and to notice particularly the numbers and formulæ. What does not please you, alter at once. I have often felt that there was something not quite right, without being able to find what was right."

I shall not attempt to dwell upon the outcome of this great work. The investigation on the radicle of benzoic acid will ever remain one of the greatest achievements in the history of organic chemistry: the work was indeed epoch-making in the far-reaching nature of its consequences. It was full of facts and rich in the promise of new material; a veritable mine from which subsequent workers like Cannizzaro, Fehling, Piria, Stas, and Hlasiwetz have dug rich treasure. The immediate effect of the paper was to establish the doctrine of organic radicles by demonstrating the existence of groups of bodies which had their analogues and prototypes in inorganic chemistry. The concluding words of the memoir strike, in fact, the keynote of the whole investigation. "In once more reviewing and connecting together the relations described in this memoir," so wrote Liebig and Wöhler, "we find that they may be grouped round a common nucleus which preserves intact its nature and composition in its associations with other bodies. This stability has induced us to regard this nucleus as a kind of compound element, and to propose for it the special name of 'benzoyl.'"

A significant feature in the memoir was that each of the substances described and correlated was the type of a distinct group of bodies, some of which were known, but of which the analogies and relations were unthought of; others of these bodies were yet to be discovered, a matter of little difficulty when the modes of their origin had been indicated. The effect of this memoir on the chemical world was instantaneous. Berzelius was delighted. "The facts put forward by you," he wrote to Wöhler and Liebig, "give rise to such considerations that they may well be regarded as the dawn of a new day in vegetal chemistry. On this account I would propose that this first-discovered radicle composed of more than two elements should be named *proin* (from πρωΐ, the beginning of day) or *orthrin* (ὄρθρος, daybreak), terms from which names like *proic acid*, *orthric acid*, *proic chloride*, *orthric chloride*, &c., could be readily derived."

Wöhler remained in Cassel for nearly five years. In the autumn of 1835 died Strömeyer, Professor of Chemistry in the University of Göttingen. Opinions were divided as to his successor; the choice lay between Liebig and Wöhler. Eventually Wöhler was selected, and entered on his work at Göttingen in the early part of 1836. He was succeeded at Cassel by Bunsen, who was at that time *privat docent* in Göttingen. In the October of that year Wöhler was again ready for fresh work. He writes to Liebig: "I am like a hen which has laid an egg and straightway sets up a great cackling. I have this morning found how oil of bitter almonds containing prussic acid may be obtained from amygdalin, and would propose that we jointly undertake the further investigation of the matter, as it is intimately related to the benzoyl research, and it would seem strange if either of us should work alone again in this field, denn es lässt sich gar nicht absehen wie weit es sich erstreckt, und ich glaube es ist gewiss fruchtbar, wenn es mit Deinem Mist gedüngt wird. . . ." In a couple of days afterwards Wöhler was ready with the fundamental facts for the research and had sketched out its plan. He writes:—

"I have just made a most remarkable discovery in relation to the amygdalin. Since it appeared that bitter almond oil might be obtained from amygdalin, it occurred to me that the one might be converted into the other by simply distilling almonds with water by an action similar to that of a ferment upon sugar, the change in this case being due in all probability to the albumen in the almonds. And this idea seems to be completely established. The facts are as follows:

"1. Amygdalin, dissolved in water and digested with a bruised sweet almond, begins almost immediately to smell of bitter almond oil, which after a time may be distilled off in such quantity that it would appear that the amygdalin was wholly transformed into it.

"2. A filtered emulsion of sweet almonds produces the same effect.

"3. A boiled emulsion of sweet almonds, in which, therefore, the albumen is coagulated, affords not the smallest trace of oil with amygdalin.

"4. Bruised sweet almonds, covered with alcohol, and freed therefrom by pressure, transform, as before, amygdalin into bitter almond oil.

"5. Bruised peas, or the albumen they contain, give no oil with amygdalin.

"There are three points, therefore, to be ascertained—

"*a.* What is the substance in bitter or sweet almonds which, in contact with amygdalin and water, forms bitter almond oil?

"*b.* Is the action by double decomposition or catalytic, like that of a ferment?

"*c.* What is the other product which in all probability is formed in addition to the oil and prussic acid?"

The merest tyro in organic chemistry to-day is familiar with the broad features of this investigation, and knows the answers which Liebig was able to give to his friend's interrogatories. The third substance Liebig discovered to be sugar. Under the influence of a nitrogenised ferment, termed by Liebig and Wöhler *emulsin*, amygdalin, in presence of water, is decomposed into benzaldehyde (bitter almond oil), prussic acid, and sugar (glucose), thus:—

$$\underset{\text{Amygdalin}}{C_{20}H_{27}NO_{11}} + \underset{\text{Water}}{2H_2O} = \underset{\text{Benzaldehyde}}{C_7H_6O} + \underset{\text{Prussic acid}}{CNH} + \underset{\text{Glucose}}{2C_6H_{12}O_6}.$$

It simply remains to explain why this reaction only occurs when the almonds are bruised and digested with water. Both the emulsin and the amygdalin exist together in the almonds, but are contained in separate cells, and are only brought into contact by the rupture of the cell-walls and the solvent action of the water. Amygdalin was the prototype of a large and important group of substances classed together as the glucosides.

At the instigation of Wöhler, the friends again returned to the question of the chemical nature of uric acid, and the memoir which they eventually published on the subject is of the profoundest interest, not only to the chemist, but also to the physiologist. Uric acid, originally discovered by Scheele, was shown in 1815, by William Prout, then a boy of nineteen, to be the main constituent of the solid excreta of reptiles; other chemists had succeeded in obtaining various derivatives from it, indeed Prout himself had prepared from it the so-called purpuric acid, a substance which years after as murexide obtained a transitory importance in the arts as a colouring matter. But nothing was known concerning the constitution of the body or of its relations to its derivatives until Wöhler and Liebig attacked the problem. The extraordinary mutability of uric acid, which had baffled and deceived previous investigators, was to Wöhler and Liebig the very clue to the labyrinth leading to a veritable treasure-house, and the wonderful insight and rare analytical skill of these two great men were never more clearly indicated than in the way in which they trod this intricate maze. No fewer than fifteen new bodies were added to the list of chemical compounds, and these were correlated with the same masterly lucidity that was so strikingly exhibited in the memoir on the radicle of benzoic acid. Some of the greatest triumphs of modern chemistry are seen in the synthesis of organic bodies. That organic chemistry was about to advance along this line was clearly foreseen by Wöhler and Liebig. In opening their account of this the last great work they did in common, they say:—"From this research, the philosophy of chemistry will draw the conclusion that the ultimate synthetical formation in our laboratories of all organic bodies, in so far as they are not organised (in so weit sie nicht mehr dem Organismus angehören), may be regarded as not only probable but as certain. Sugar, salicin, morphin will be artificially obtained. As yet we know nothing of the way by which this result is to be attained, inasmuch as the proximate materials for forming these bodies are unknown; but we shall come to know them."

Henceforth the friends worked but little in common. Liebig's energies were spent in other directions, and Wöhler turned his attention to inorganic chemistry. Time allows only the very briefest mention to be made of his more important discoveries in this department of the science. We have first his isolation of crystalline boron, and the preparation of the compounds of boron with aluminium and nitrogen, work done in concert with Sainte-Claire Deville. The readiness with which boron unites with nitrogen, and the mode in which the compound may be decomposed, led Wöhler to a conception of the origin of boric acid and borax in the volcanic waters in which they are frequently found. In collaboration with Buff he discovered the spontaneously inflammable hydride of silicon, the analogue of marsh gas, the simplest of the hydrides of carbon, and thereby laid the foundation-stone of a superstructure, which in time to come may only be less imposing than that built up of the compounds of carbon. Many years ago Wollaston noted the presence of beautiful lustrous copper-coloured cubes in the slags from the iron blast-furnaces, which he assumed to be metallic titanium; Wöhler proved this substance to be a compound of carbon, nitrogen, and titanium, and showed how it might be obtained. Of all the elements known to the chemist up to the period of Wöhler's cessation from work, it may be safely averred that there was not one but had passed through his hands in some form or other. Now he was busy with chromium, then with cerium, next with uranium and the platinum metals; titanium, tantalum, thorium, thallium, tungsten—all came in for some share of his attention. Of the minerals and meteorites he analysed, the number is legion; indeed, as Prof. Hofmann says, whoever sent him a piece of meteoric iron gained his heart. His restless activity was a source of continual wonder to his friends. "How happy art thou in thy work!" wrote Liebig on one occasion; "thou art like the man in the Indian fable, who when he laughed dropped rose from his mouth."

The names of Liebig and Wöhler are now so closely intertwined in the history of chemistry that it is hardly possible to avoid comparing the men. Such a comparison has already been drawn by one who of all others is most fitted to draw it. "Liebig," says Dr. Hofmann, "fiery and impetuous, seizing a new thought with enthusiasm, and giving to it the reins of his fancy, tenacious of his convictions, but open to the recognition of error, sincerely grateful, indeed, when made conscious of it,—Wöhler, calm and deliberate, entering upon a fresh problem after full reflection, guarding himself against each rash conclusion, and only after the most rigorous testing, by which every chance of error seemed to be excluded, giving expression to his opinion—but both following the path of inquiry in their several ways, and both animated by the same intense love of truth! Liebig, irritable and quick to take offence, hot-tempered, hardly master of his emotions, which not unfrequently found vent in bitter words, involving him in long and painful quarrels,—Wöhler, unimpassioned, meeting even the most malignant provocation with an immovable equanimity, disarming the bitterest opponent by the sobriety of his speech, a firm enemy to strife and contention—and yet both men penetrated by the same unswerving sense of rectitude! Can we marvel that between two such natures, so differently ordered, and yet so complementary, there should ripen a friendship which both should reckon as the greatest gain of their lives?"

Who can fully gauge the influence of such a nature as Wöhler's? How it was exerted on Liebig is indicated in the following letter:—

"FREDERICK WÖHLER TO JUSTUS LIEBIG

"*Göttingen, March* 9, 1843

"To make war against Marchand, or, indeed, against anybody else, brings no contentment with it, and is of little use to science. . . . Imagine that it is the year 1900, when we are both dissolved into carbonic acid, water, and ammonia, and our ashes, it may be, are part of the bones of some dog which has despoiled our graves—who cares then whether we have lived in peace or anger; who thinks then of thy polemics, of the sacrifice of thy health and rest for science?—Nobody. But thy good ideas, the new facts which thou hast discovered, these, sifted from all that is immaterial, will be known and remembered to all time. But how comes it that I should advise the lion to eat sugar!"

It was thus in philosophic contentment, happy in his work, in his home life, and in his friendships, that Wöhler lived out his fourscore years and two. He made Göttingen famous as a school of chemistry; at the time of the one-and-twentieth year of his connection with the university it was found that upwards of 8000 students had listened to his lectures or worked in his laboratory. He was a man whom the world has delighted to honour; and there was hardly an academy of science or a learned society which has not in some way or other recognised his services to science. He was made a Foreign Member of the Royal Society in 1854, a Corresponding Member of the Berlin Academy in 1855, Foreign Associate of the Institute of France in 1864, and in 1872 he received the Copley Medal from the Royal Society. On September 23, 1882—

" He gave his honours to the world again,
His blessed part to heaven, and slept in peace."

METEORIC DUST

SIR WILLIAM THOMSON has sent us the following communication for publication:—

"*Portkil, Kilcreggan, March* 13, 1884

"DEAR SIR WILLIAM THOMSON,—Herewith I inclose some of the meteoric dust collected on a cotton filter, and both ignited at a red heat. The change of colour is interesting.

"On Saturday, March 1, the snow lay 5½ inches deep at 8 a.m., pure and white. At 9.15 a.m., when I next noticed it, it was sooty looking, the blackish appearance penetrating half an inch only. The sky was clear and calm, any tendency to movement of the air being from the south-east.

"I carefully measured a superficial foot on an outlying field sloping to the south-west at a spot bisected by the 200-foot line of the Ordnance Survey, and collected the snow into two bowls of white delft, half into each. After evaporating the snow water, thoroughly drying the residue, I collected and weighed it, that from one giving 1⅞ grains, and the other 2⅛ grains, or 4 grains to the square foot exactly.

"I can personally vouch for the dust being all over the Roseneath peninsula, as I trudged through the snow to Coulport on Loch Long, and found it the same all the way north, also on the top of the Gallow-hill (414 feet). I have since seen those who noticed it at Garelochhead, so that on this peninsula alone, taking 4 grains as an average, there has fallen over 100 tons.

"From hearsay it appears to have been noticed from Kippen on the north to Largs on the south, and from Hamilton on the east to Dunoon on the west, or over an area (in round numbers) of 810 square miles, and admitting the former estimate, we have the astonishing aggregate of say 5760 tons! A weighty gift to Mother Earth, surely of some value.

"I should mention that every crack, scratch, or depression in the glaze of the bowls was filled with the finely divided matter; it was impossible, therefore, to collect it *all* for weighing, consequently 4 grains per square foot is under rather than over the probable average. The observer at Kippen, too, mentions that the snow was permeated there for one inch by the sooty appearance.

"On Monday (March 3), after snow had fallen to the depth of an additional 8 inches, I watched for a recurrence of the phenomenon, and on the sky clearing about midnight I fetched in a dish that I had left outside and found a little had fallen in small flakes; these had melted their way through the snow, leaving little tunnels about the size of crow-quills. The quantity, however, was exceedingly small. Tendency to movement of the air as before from the south-east. Barometer had risen from 29·4 at 2 p.m. to 29·6, steady at midnight, thermometer 42°. On Saturday previous barometer stood at 30·05 (90 feet above sea-level, aneroid), thermometer 44°, 12 noon. The dust I left with you previously contains a little organic matter (grassy fibre), though what I had under the microscope appeared entirely metallic.

"The snow had melted a good deal before I recognised the importance of obtaining a fair sample. My children, however, had rolled a huge snowball down the slope, at the top of which the cottage stands, and this had increased as it rolled until it was something like 6 feet in diameter, and so formed a mine from which to collect the dust. There is still some of the black water in process of evaporation; should you require it more of the dust is at your service.

"One of the older inhabitants remembers a similar occurrence here in 1828 on the 20th or 22nd of March, when the snow, he says, fell in black or sooty flakes.

"Perhaps it is well to mention that the goats suffered somewhat from influenza on Sunday and Monday, and that I myself had a sharp attack followed by severe headache for a day, caused probably by inhaling a minute quantity of the dust snuff fashion. It might have been from something else, only the coincidence is suggestive of caution.

"I am, yours faithfully,
"LEWIS P. MUIRHEAD

"Professor Sir William Thomson, Glasgow University"

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The Boards for Medicine, Physics and Chemistry, and Biology and Geology, after joint deliberation, have recommended an important change in the appointments of Natural Science Examiners. It has been a regulation of the Natural Science Tripos that all answers shall be looked over by two examiners out of the eight, but it has become increasingly difficult to find examiners with the requisite extent of knowledge. Thus it practically happens that each examiner is sole examiner in a single subject, and the places of candidates are often practically dependent on the judgment of a single examiner to an extent unknown in the other Triposes. It is now recommended that two examiners shall be appointed in each subject of Natural Science, to undertake all the University Examinations in that subject, and thus the Natural Sciences Tripos, the Special Examinations for the ordinary B.A., and portions of the M.B. Examinations, will be brought into one system. The examiners should never both be changed at the same time. The payments recommended are—for each examiner in Physics and in Chemistry, 50*l.*; in Botany, Zoology, Human Anatomy, and Physiology, 40*l.*; in Geology, 20*l.*; and Mineralogy, 10*l.*

SCIENTIFIC SERIALS

Journal of the Franklin Institute, No. 697, January.—W. Dennis Marks, note on the losses per horse-power by condensation of steam in pipes and cylinders of engines.—De Volson Wood, the cheapest point of cut-off.—Prof. R. H. Thurston, the theory of turbines. This is the conclusion of a very valuable mathematical paper given in a very full abstract.—B. N. Clark, water-line defence and gun-shields for cruisers.—W. Dennis Marks, economy of compound engines.—Prof. E. J. Houston, the Delany synchronous-multiplex system of telegraphy. This invention is founded on La Cour's phonic wheel, and bids fair to supersede harmonic multiple telegraphs.

Annalen der Physik und Chemie, xxi. January.—O. Fröhlich, measurements of sun-heat. Describes amongst other matters a new pyrheliometer with a special thermopile arrangement.—A. W. Velten, the specific heat of water. The results confirm Regnault's values.—E. Pirani, on galvanic polarisation. The values are estimated by a compensation method.—W. Hittorf,